Minnesota's New Science Star lards:
A "Top 10" List for District Adm istrators

The *Minnesota Academic Standards in Science* has been evised to reflect new expectations for the achievement of all students. Here are en things to keep in mind as you plan your district's implementation of the standards.

1. Districts should begin their planning activities no in order to be fully ready for implementation by the 2011 - 2012 school year. hat is the year the MCA III Science Assessment will be based on the new sta lards

2. Some major differences between the 2004 and th 2009 standards:
   - The standards and benchmarks are writte for specific grades in K – 8. Previously they could be assigned within rade bands of K-2, 3-5 and 6-8.
   - There are some new areas of emphasis in ıe standards, including engineering design and applications of sc nce.
   - Some ideas have been removed, others ac ed and some have been moved to different grade levels. The net effect o these changes is a similar number of benchmarks in the 2004 and th 2009 standards.

   Other important differences include the followin —
   - College and work readiness skills are inte rated into all strands.
   - Numerous examples are provided in the b nchmarks to increase understanding of the standards.
   - Greater coherence in the development of kills and concepts within grade levels and among grade levels.
   - The focus of the standards in the middle hool years is:
     - 6th grade – physical science
     - 7th grade – life science
     - 8th grade – earth science

3. Minnesota's standards are placed at the grade le l where *mastery* is expected. Concepts and skills for a particular standard ma need to be introduced at earlier grades to develop those abilities.

4. Provide teachers with multiple opportunities to r ad, understand and discuss standards at all grade levels, but especially the s ndards for grades below and above their own grade level which relate to thei standards.

5. Provide opportunities for conversation followin the curriculum mapping process. The "mechanical" process of mapping identifies gaps and overlap in the district's delivery of the standards. But the process of sta lards implementation doesn't end here. Encourage thoughtful conversations a ong teachers focused on the question, "What should we be doing differently

Curriculum Alignment Template

Benchmark Code/Idea	Curriculum Materials Reference	Supplemental Materials	Needs

Standards- and Research-Based Study of a Curricular Topic

SOUND

Section and Outcome	Selected Sources and Readings for Study and Reflection Read and examine *related parts* of:
I. Identify Adult Content Knowledge	**IA:** ***Science for All Americans*** ▸ Chapter 4, *Motion*, pages 52–55 **IB:** ***Science Matters: Achieving Scientific Literacy*** ▸ Chapter 2, *Other Kinds of Energy*, pages 23–24
II. Consider Instructional Implications	**IIA:** ***Benchmarks for Science Literacy*** ▸ 4F, *Motion* general essay, pages 87–88; grade span essays, pages 89–91 **IIB:** ***National Science Education Standards*** ▸ Grades K–4, Standard B essay, pages 123, 126; Vignette *Musical Instruments*, pages 47–49 ▸ Grades 5–8, Standard B essay, pages 149, 154 ▸ Grades 9–12, Standard B essay, pages 177–178
III. Identify Concepts and Specific Ideas	**IIIA:** ***Benchmarks for Science Literacy*** ▸ 4F, *Motion*, pages 89–92 **IIIB:** ***National Science Education Standards*** ▸ Grades K–4, Standard B, *Light, Heat, Electricity, and Magnetism*, page 127 ▸ Grades 5–8, Standard B, *Transfer of Energy*, page 155 ▸ Grades 9–12, Standard B, *Interactions of Energy and Matter*, page 180
IV. Examine Research on Student Learning	**IVA:** ***Benchmarks for Science Literacy*** ▸ 4E, *Energy Forms and Energy Transformation*, page 338 **IVB:** ***Making Sense of Secondary Science: Research Into Children's Ideas*** ▸ Chapter 4, *Hearing*, pages 45–46 ▸ Chapter 18, *Sound*, pages 133–137
V. Examine Coherency and Articulation	**V:** ***Atlas of Science Literacy*** ▸ *Waves*, pages 64–65
VI. Clarify State Standards and District Curriculum	**VIA:** ***State Standards:*** Link Sections I–V to learning goals and information from your state standards or frameworks that are informed by the results of the topic study. **VIB:** ***District Curriculum Guide:*** Link Sections I–V to learning goals and information from your district curriculum guide that are informed by the results of the topic study.
Visit www.curriculumtopicstudy.org for updates or supplementary readings, Web sites, and videos.	

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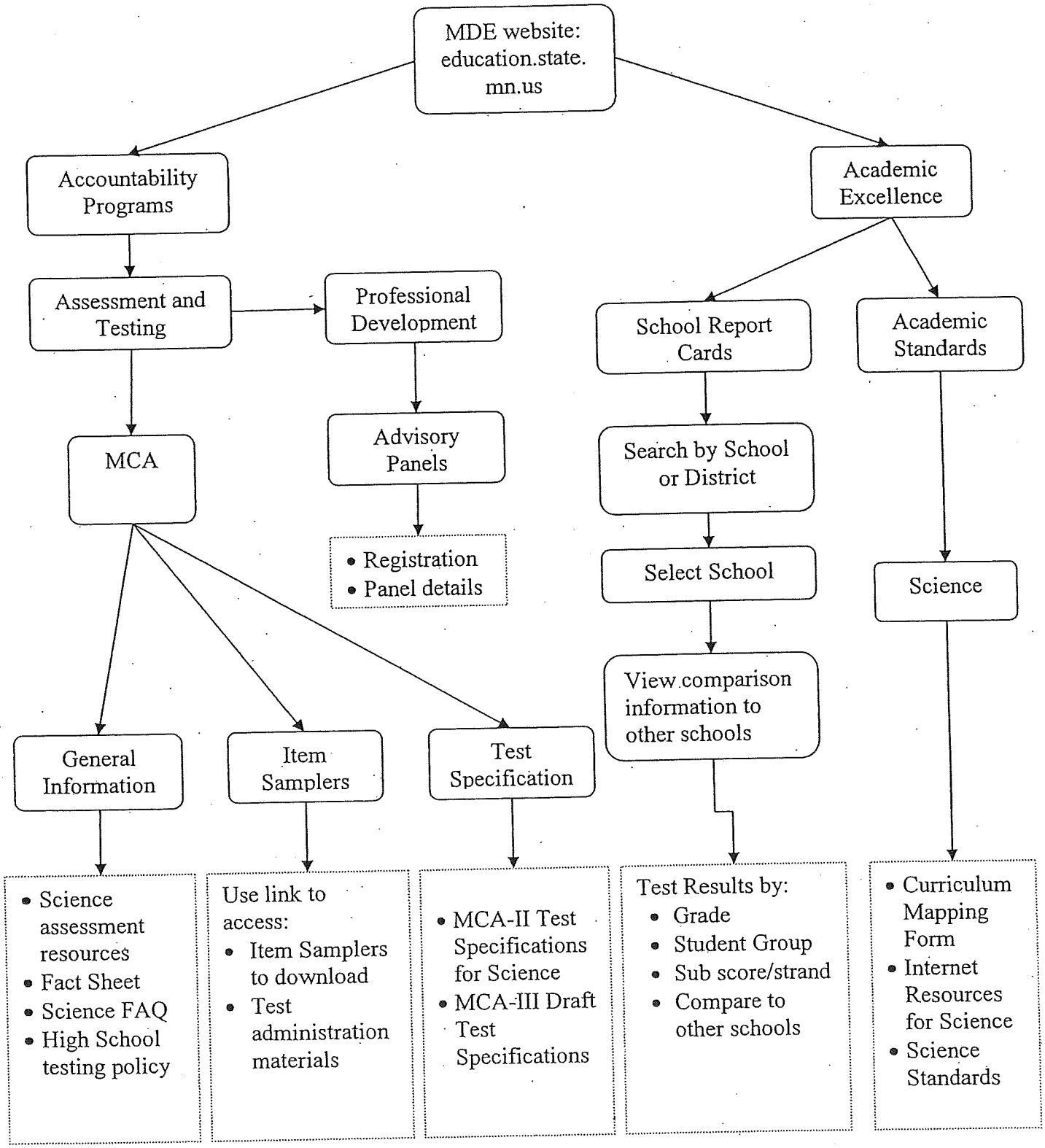
Science MCA-II Resources on the MDE Website



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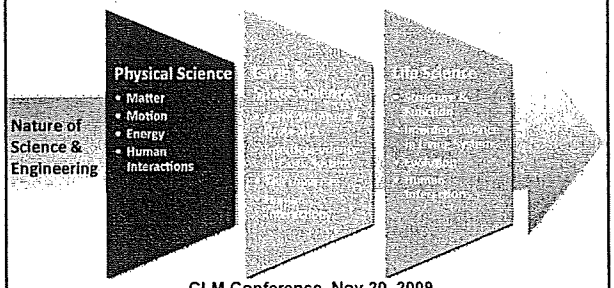
Aligning Curriculum to the New Science Standards



CLM Conference, Nov 20, 2009

John Olson, MDE School Improvement Specialist - Science

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Agenda

- What is new in the standards?
- What changes in curriculum will be needed?
- What are some strategies for aligning curriculum?
- What resources are helpful?

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Current Status - Requirements

- Graduation Requirements
  - 3 credits (courses) in science in high school
    - One must be in biology
    - Starting with class of 2015, one must be in chemistry or physics
- Graduates who take the following courses in high school: (statewide estimates)
  - Biology – 100%
  - Chemistry – 50%
  - Physics – 25%

Current

chemistry : physics →

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Current Status: Minn. Standards

- Current Standards – 2004
- Science MCA-II began 2008
- Revision of Standards 2009
  - Revision Committee March 2008 – Feb 2009
  - 30 members including K-12, higher education, community members
  - Currently going through Rulemaking process
- Implementation of new standards 2011-12
- MCA-III, based on the new standards, begins spring 2012, no "constructed response"

Current grades 3 & 6 tested in 2012

Legislative Mandates

- Must be written at grade level K-8
- Aligned with post-secondary and work readiness
- Include technology/engineering and information literacy
- Include environmental literacy
- Include contributions by Minnesota American Indian communities

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Goal of the Science Standards

- **Have ALL students interacting with the world as Scientists . . .**
  - **investigate how the world works**
  - **think analytically & make evidence-based decisions**
  - **learn and apply science concepts**
- **and Engineers.**
  - **design solutions to problems and needs**
  - **examine how science and technologies are used in the designed world**

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What is Engineering?

- **Engineering Design** – applying a variety of processes used to solve problems.
- **Understandings About Engineering** – learning how science, math and other areas are applied to produce the built-world
- Comparisons:
  - **Science** seeks to explain the processes in the natural world.
  - **"Technology"** refers to the products and process that result from the engineering process.

Comparison of typical processes

Science Inquiry	Engineering Design
• Observation and form a question	• Define the problem and the resources available
• Hypothesis & procedure	• Develop a design
• Conduct an experiment	• Test the design
• Refine hypothesis and experiment again	• Modify the design and test again
• Form a conclusion and communicate it	• Analyze the design and use or market it
Result: Facts & theories	Result: Products & processes

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Why is Engineering in the Science Standards?

- Helps understand our built world
- Provides problem solving skills needed by everyone
- Applies science and strengthens concepts
- Addresses workforce and competitive concerns
- Exposes career possibilities
- Meets legislative/MDE requirement

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What should students learn about engineering?

- How to use design processes
- Considers the constraints, costs, & benefits and makes trade-offs
- Evaluates the source, use, & disposal of materials
- Has an impact on society and is influenced by society
- Is a possible career

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5 Steps of Science Lesson Planning
- Engage
- Explore
- Explain
- Elaborate (apply)
- Evaluate

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How Can We teach Engineering?

- Find a curriculum?
  - Engineering Is Elementary, Gateway, Project Lead the Way, several others!
- Add a special unit?
- Go on a field trip?
- Bring in an engineer for a presentation?
- Include it in content instruction!

An Example

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In teaching heat transfer, a teacher challenges students to design a container to keep a cup of hot water as hot as possible over a time period.

Science Questions	Engineering Questions
1. How were convection, conduction, radiation and evaporation involved?	1. How did you develop and test the design?
2. What are the variables that affected heat transfer?	2. What were the advantages and disadvantages of the materials you tried?
3. Which variables were controlled?	3. What were the constraints and trade-offs involved?
	4. How would you use and market your ideas?

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Organization of the Standards

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I. Nature of Science and Engineering 1. Practice of Science 2. Practice of Engineering 3. Interactions Among STEM and Society	III. Earth and Space Science 1. Earth Processes 2. Interdependence 3. Universe 4. Human Interactions
II. Physical Science 1. Matter 2. Motion 3. Energy 4. Human Interactions	IV. Life Science 1. Structure & Functions 2. Interdependence 3. Evolution in Living Sys. 4. Human Interactions

Cross-cutting nature of the strands

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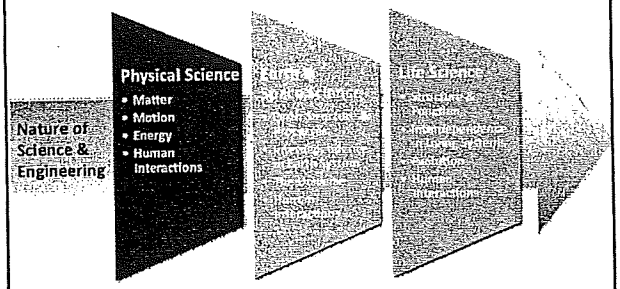

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Format of Standards and Benchmarks

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	Strand	Sub-Strand	Standard Understand that...	Code	Benchmark
4	1. Nature of Science & Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution and building the product.	4.1.2.2.1	Identify and investigate a design solution and how it was used to solve an everyday problem. *For example:* Investigate a variety of construction tools.

- **Standards** = general goal of student learning.
- **Benchmarks** = specific knowledge & skills acquired by the end of the grade
- **Examples** - for clarification and level of understanding, NOT curriculum directives

- At grade levels K-8 (required) & 9-12 band
- Grade of mastery (scaffolding needed before)

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Comparison of 2004 & 2009

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Similarities

- Structure – strands, substrands, standards, benchmarks
- Emphasis on inquiry and nature of science
- Similar number of benchmarks

New Features

- Substrands are reorganized
- Some grade changes and topic consolidation
- New areas: engineering, environment, STEM connections,
- Physics & Chemistry course standards are added
- Similar "grain-size"
- More specific + examples
- Consistent numbering

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Curriculum Implications

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- Elementary (K-5): may need to
  - Switch topics between grades
  - share some curriculum materials
  - add some new curriculum resources
- Middle Schools:
  - Align to this sequence:
    - 6th Physical Science
    - 7th Life Science (plus some physical science)
    - 8th Earth Science (plus some physical science)

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High School Course Realignment

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- Requirements to Consider
  - All students must receive instruction in all standards
  - Credit requirements – 3 credits
    - 1 Biology, 1 physics or chemistry for class of 2015
    - Ag. Science or CTE may count as a general science credit
  - Licensure: 5-8 general can teach integrated science, including 9th physical science
  - MCA assessment given in year of the biology course
- Other Factors
  - Sequence of learning, prerequisite skills (math)
  - Electives: interests, advanced courses

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Curriculum Planning

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- Suggested Implementation Schedule
  - 2009-10: 3rd & 6th (first classes to take MCA on revised standards)
  - 2010-11: 2nd, 4th & 7th, 9th, other pre-biology
  - 2011-12: K, 1st, 5th, 8th, biology
  - 2012-13: chemistry and physics alignment

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Curriculum Planning Process

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1. Begin with content standards and benchmarks
   - Look at the progression of the ideas from previous grades and to later grades. Refer to the *Atlas of Science Literacy.*
   - Identify instructional resources & needs
2. Look at Nature of Science & Engineering standards and benchmarks
   - Identify opportunities for embedding into content instruction
3. Start developing unit plans with activities
   - Suggestion: use backwards design

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Am. Assn. for the Advancement of Science (AAAS) Project 2061 (started 1985)

Project 2061 believes...

- Science literacy is important for **all** students, not only those electing science careers.
- "Science" includes natural science, social science, mathematics, and technology.
- There are no quick fixes.
- Curriculum should cover less material but at greater depth.
- Reform must be structured around powerful, meaningful goals.

Project 2061 (AAAS)

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Science For All Americans (SFAA)- 1990

- What ALL students should know and be able to do by the end of high school (Science, Math, Technology)
- Defines Science Literacy

Benchmarks for Science Literacy (BSL)-1993

- Lists what students should know and do at end of grades 2, 5, 8 & 12. Includes teaching strategies.

Online at: http://www.project2061.org/

Project 2061 (AAAS)

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Contents of SFAA & BSL

1. **The Nature of Science**
2. **The Nature of Mathematics**
3. **The Nature of Technology**
4. **The Physical Setting**
5. **The Living Environment**
6. **The Human Organism**
7. **Human Society**
8. **The Designed World**
9. **The Mathematical World**
10. **Historical Perspectives**
11. **Common Themes**
12. **Habits of Mind**

Project 2061 (AAAS)

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Atlas of Science Literacy (2001, 2007)

- Strand maps that show the growth and connection of concepts
- Summary of research on misconceptions
- Interactive maps at: www.nsdl.org called "Science Literacy Maps"

National Research Council

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***National Science Education Standards* (NSES) 1996**

- Teaching Standards
- Professional Development Standards
- Assessment standards
- Content Standards
- Program Standards
- System Standards

http://www.nap.edu/html/nses/

National Science Education Standards

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Content Standards

K-4, 5-8, 9-12

1. Science as Inquiry
2. Physical Science
3. Life Science
4. Earth & Space Sci.
5. Science & Technology
6. Science in Personal & Social Perspectives
7. History and Nature of Science

Online at: www.nap.edu/catalog/4962.html

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Other Resources

Science Curriculum Topic Study by Page Keeley

- Organized by topics
- References to national standards and major references
- http://www.curriculumtopicstudy.org/

Making Sense of Secondary Science by Rosalind Driver

- Research on science pre-conceptions
- Can be read online at Google books

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Impact on MCA Testing

- Tests are given at grades 5, 8 and high school (end of biology course)
- The new standards will be used for the MCA-III science assessment beginning in the 2011-12 school year
- Test Specifications for MCA-III have been drafted. The comment period is open.
- Resources are available for student practice

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MCA-III Test Specifications Format

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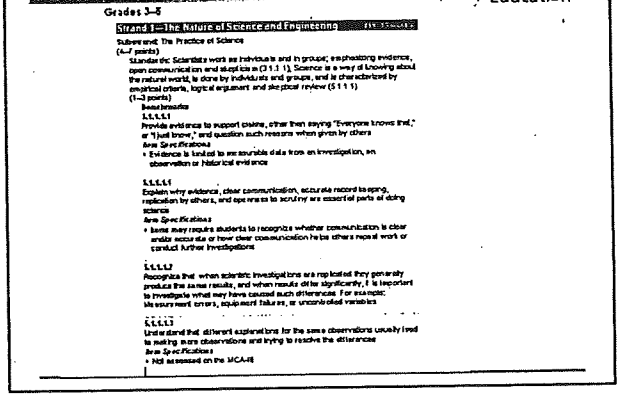

Grades 3–5

Strand 1—The Nature of Science and Engineering

Substrand: The Practice of Science

(4–7 points)

Standard: Scientists work as individuals and in groups; emphasizing evidence, open communication and skepticism (5.1.1.1). Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review (5.1.1.1)

(1–3 points)

Benchmarks

5.1.1.1.1

Provide evidence to support claims, other than saying "Everyone knows that," or "I just know," and question such reasons when given by others

Item Specifications

- Evidence is limited to measurable data from an investigation, an observation or historical evidence

5.1.1.1.2

Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are essential parts of doing science

Item Specifications

- Items may require students to recognize whether communication is clear and/or accurate or how clear communication helps others repeat work or conduct further investigations

5.1.1.1.3

Recognize that when scientific investigations are replicated they generally produce the same results, and when results differ significantly, it is important to investigate what may have caused such differences. For example: measurement errors, equipment failures, or uncontrolled variables

5.1.1.1.4

Understand that different explanations for the same observations usually lead to making more observations and trying to resolve the differences

Item Specifications

- Not assessed on the MCA-III

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Student practice options

- Classroom Assessment System
  - Available through District Assessment Coordinator
  - Includes teacher manual and scores generated for students
- Item Samplers
  - Available on the MDE website to public
  - Does not generate scores automatically

Additional Resources

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- Standards Workshops: MDE Dec 2, 9 + ?
- Minnesota Science Teachers Assn.
  - Spring Conference with Elementary Strand, Willmar, April 15 – 17
  - Newsletter, discipline conferences, www.mnsta.org
- Science Teacher Partnership
  - Partnership of cooperative unit, college, district
  - 2010-11: Grade 3-6 Nature of Science & Engineering
- Informal Ed, Colleges and Industry
  - Science Museum, The Works, Bakken Museum
  - Engineering departments, local industries
- Elementary Engineering Conference – Jan 28

Contacts

Department of Education

- http://education.state.mn.us →Academic Standards → Science - standards, supporting documents, link for comments and assessment
- John.C.Olson@state.mn.us, - Science Specialist, 651-582-8673
- Jim.Wood@state.mn.us – Science Assessment Specialist, 651-582-8541
- Dawn.Cameron@state.mn.us – Science Assessment Specialist, 651-582-8551
- http://www.getstem-mn.com – resources and events

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Standard/Benchmark Summary
Minn. Academic Standards in Science – 2009
Rough DRAFT 11.19.09

Nature of Science & Engineering

	Practice of Science	Practice of Engineering	Interactions: STEM & Society
K	Scientific inquiry: -Using observations for descriptions	Engineering design: - Compare natural and human made objects	
1	Understandings about science: - using observations as evidence, - describing accurately		Systems: - parts related to function Careers and contributions: - tools used to gather information & solve problems
2	Scientific inquiry: -raise questions & seek answers by observations, and sharing answers	Engineering design: - constructing an object to meet a need	
3	Understandings about science: -support claims with evidence and question claims of others Scientific inquiry: -generate question that can be investigated - repeatability of investigations - record of observations, procedures & explanations - constructing explanations based on evidence		Careers and contributions: - everyone uses evidence - involvement of various people and kinds of work Role of math and technology: - use of tools to improve observations and keep records
4		Understandings about engineering: - positive and negative impacts of designed world on the natural world Engineering design: - Investigate a design and its use - generate ideas and constraints for solving a problem -test and evaluate a solution	STEM and society - one invention leading to another
5	Understandings about science: - use of evidence, communication, and openness to scrutiny - replication should produce same results - resolving conflict in different explanations - use of models to represent phenomena and the limitations of models Scientific inquiry: -matching scientific question with investigation method - Collect relevant evidence and observations with concern for variables - Note fairness criteria in experiments including controls and repetitions.		Careers and contributions: - influence of local traditions and beliefs Role of math and technology: - appropriate tools and techniques for handling data - use of various kinds of maps

6		Understandings about engineering: - impact of a engineered system on daily life -risks of new technologies - trade-offs in using products -learning from past failures Engineering design: - apply and document a design process to solve a problem	Systems: - describe subsystems, inputs, processes and output - open vs. closed systems Role of math and technology: - use of procedures, measurements and math analyses - conversion of metric units
7	Understandings about science: - role of prior expectations - judging the reliability of results Scientific inquiry: - selecting appropriate question and methods of investigation - conduct controlled experiment with multiple variables - generate conclusions with evidence and explanations -evaluate explanations by others		Use of technologies and models: - use of images and data sets in life science - use of procedures, measurements and math analyses in life science
8	Understandings about science: - reasoning involved with fact, opinions and evidence Scientific inquiry: - use reasoning and imagination to develop explanations and models.		Careers and contributions: - contributions to STEM by individuals of different cultures STEM and society - role of economic, political, social and ethical expectations -changing nature of scientific knowledge as influenced by new technologies - impacts of new technologies on society
9-12	Understandings about science: - universality of science laws - purposes of scientific investigations - norms of science - role of societal and scientific ethics - influence of bias - knowledge based on incremental advances - how theories and models change Inquiry: - experimentation with emphasis on alternative explanations and conclusions supported by evidence - evaluate explanations proposed by others, especially reasoning and evidence - analyze assumptions and logic - use scientific writings to study methods used by scientists	Understandings about engineering: - Critiquing designs and products - use of risk analysis - consideration of manufacturing, maintenance and disposal Engineering design: - identifying constraints on a possible solution - use of models to evaluate possible solutions	Systems: - specifying boundaries, subsystems, relationships, inputs and outputs - comparison of system properties to that of its parts - positive and negative feedback in systems Careers and contributions: - contributions of diverse cultures to science, math and technology - analysis of STEM careers

Physical Science

	Matter	Motion	Energy	Human Interactions with Physical Systems
K	Properties & structure: - object color, size, shape and texture			
1				
2	Properties & structure: - object weight, texture, flexibility, strength and materials Changes in matter: - changes between solids and liquids	Describing motion: - changes in position - variety of motions and speeds Forces: - forces to make objects move - falling to the ground		
3			Kinds of energy: - factors that affect pitch of sound - forming shadows - light travel and interactions with surfaces	
4	Properties & structure: - measuring temperature, volume, weight and lengths Changes in matter: - comparison of solids, liquids and gases - change in state based on heating & cooling		Kinds of energy: - transfer of heat by contact - forces from magnets - conductors of heat and electricity Energy transformations: - ways to generate heat - simple electric circuits - electric current producing magnetism	
5		Describing motion: - forces and motion in simple machines - effect of forces on speed and direction of motion - relation of force to changes in motion		
6	Properties & structure: - use of particle model to explain properties Changes in matter: - evidence of physical changes - conservation of mass during physical changes - particle arrangement and motion in solids, liquids and gases.	Describing motion: - measuring & calculating speed - graphs of position and speed Forces: - balanced forces and constant motion -forces on objects and affect on motion - contact forces vs. forces acting at a distance - comparison of mass and weight	Kinds of energy: - properties of waves - transfer of energy in sound - wave properties and behaviors of light Energy transformations: - kinetic and potential energy conversions - energy transformations in devices - heat transfer in conduction, convection and radiation	

7	Properties & structure: - elements and the periodic table groups - elements, compounds, atoms and molecules - chemical equations to describe reactions			
8	Properties & structure: - use of properties to separate mixtures and indentify pure substances - properties of metals and non-metals Changes in matter: - evidence of chemical changes - comparison of chemical and physical changes - conservation of mass in physical and chemical changes - properties of acids and bases		Kinds of energy: - energy transfer through seismic waves	
9-12	Properties & structure: - properties of protons, neutrons and electrons - evidence for atomic models - arrangements of elements on the Periodic Table - properties of isotopes Changes in matter: - valence electrons and chemical bonds - rearrangement of atoms in chemical reactions and conservation of mass - descriptions of chemical reactions - Comparison of exothermic and endothermic reactions	Forces - inertia of an object and motion - forces and acceleration - equivalence of forces between objects - gravitational forces	Energy transformations: - energy transfers in common devices - energy, work and power in mechanical systems - energy transfer through sound waves - energy transfer in simple electric circuits - interaction of electric current and magnetic force - energy and products in fission and fusion - properties and uses of electromagnetic radiation	Interaction with the environment - advantage and disadvantages of various methods of generating electricity - trade-offs involved in the use of energy, natural resources and materials

Earth & Space Science

	Earth Structure & Processes	Interdependence within the Earth System	The Universe	Human Interactions with Earth Systems
K				
1	Rock Sequences and Earth History - group rocks by some characteristics - distinguish between soil and rocks - identify objects made from Earth materials	Weather & Climate - monitor changes in weather - identify the sun as the source of heat and light		
2		Weather & Climate - measure weather with common tools		
3			Solar System Motion - describe changes in the position of the sun Formation of the Solar System - relate the size of a light compared to its distance - recognize that the Earth is one of several planets that orbit the sun and that that the moon orbits the earth	
4	Rock Sequences and Earth History - recognize that rocks contain minerals -classify minerals based on properties	Materials Cycles - identify where water collects and how it moves through the Earth systems		Interaction with the Environment - describe how the use of water can affect water supply and quality
5	Earth's Changing Surface - explain how rocks weather and form soil - explain how processes form features of the Earth's surface			Interaction with the Environment - give examples of beneficial and harmful human interactions with natural systems
6				
7				

8	Plate Tectonics - describe properties of layers of the Earth - correlate Earth features to volcanic and seismic activity - recognize geologic events that result from motion of plates. Earth's Changing Surface - explain how landforms result from geologic processes - explain how geologic process shaped Minnesota's landscape Rock Sequences and Earth History - interpret layers of rocks and fossils to infer history - classify rocks and minerals - relate rock composition to their formation	Sources and Transfer of Energy - explain causes of seasons - recognize the affect of oceans on climate - explain how heating by the sun drives convection, currents and climate Weather & Climate - describe effects of the composition of the atmosphere - analyze changes in weather indicators - relate global weather patterns to local weather Materials Cycles - describe the location, composition and use of water reservoirs-describe how the water cycle distributes materials and purifies water	Solar System Motion - compare the sun to other parts of the galaxy - describe how gravity affects objects in the solar system - recognize the gravitation force between objects - compare planets and moons - explain day length, phases of the moon and eclipses	Interaction with the Environment - describe how mineral and fuel resources formed and are used - recognize how land and water uses affect natural processes
9-12	Plate Tectonics - compare the interaction of tectonic plates at boundaries - to relate earthquake data to subduction - describe evidence for sea-floor spreading and to explain how evidence led to the theory of plate tectonics Rock Sequences and Earth History - explain how the structures of the Earth and life on Earth have changed over time - cite evidence for changes in the composition of the atmosphere as life evolved	Sources and Transfer of Energy - compare energy sources of the earth - explain the transfer of Earth's internal heat to move plates Weather & Climate - explain factors that contribute to global climate patterns - explain how evidence indicates climates changes over time Materials Cycles - trace the carbon, oxygen and nitrogen through the Earth systems	Formation of the Solar System - describe how the solar system formed - explain how Earth evolved into its habitable form - compare environmental conditions that make life possible on Earth with other objects in the solar system Age, Scale and Origin of the Universe - explain evidence for the early history of the universe - explain how nuclear fusion began in stars	Interaction with the environment - analyze the benefits, risks and trade-offs associated with natural hazards - explain how human activities and natural processes are altering Earth system

Life Science

	Structure and Function in Living Systems	Interdependence Among Living Systems	Evolution in Living Systems	Human Interactions with Living Systems
K	Levels of Organism: - compare plants and animals -indentify external parts and texture -differentiate between living and nonliving	Ecosystems: - identify living and nonliving components of a natural system		
1	Levels of Organism: -sort animals into groups according to characteristics	Ecosystems: - recognize the needs of animals -describe the ways an animal's habitat provides for its basic needs.	Reproduction - recognize that animals go through life cycles - recognize that animals pass through the same life cycles as their parents.	
2	Levels of Organism: - sort plants into groups according to characteristics.	Ecosystems: - recognize the needs of plants and they fulfill those needs in various ways	Reproduction: - describe characteristics of plants at different stages of their life cycles	
3	Levels of Organism: - compare structures of plants and animals with their functions, -identify groups of plants and animals		Variation: - give examples of likeness between adults and offspring - give examples of differences among individuals that provide an advantage for survival.	
4				Health and Disease - recognize that the body has defense systems against germs - give examples of diseases that can be prevented by vaccination
5	Levels of Organism: -describe how plant and animal structures and functions provide an advantage for survival.	Ecosystems: - describe relationships among living and nonliving parts of a natural system - explain what would happen if one of its parts were changed		Interaction with the Environment - give examples of beneficial and harmful human interactions with the environment
6				

7	Levels of Organism: - recognize the organization of cells, tissues and organs. -describe how the organs serve the needs of vertebrate organisms Cells - recognize that cells carry out life functions -recognize that they divide to make more cells. -distinguish between plant and animal cells	Ecosystems: - describe relationships among populations and communities - compare roles of populations - explain the factors that affect the number of populations in an ecosystem Flow of Energy and Matter: - recognize that producers make sugars through photosynthesis - describe how energy changes form through the food web - explain that the total amount of matter remains the same as it is transferred between organisms	Reproduction - recognize that genes determine inherited traits - compare asexual and sexual reproduction - distinguish between inherited and acquired characteristics Variation: - describe how the fossil record shows changes in life forms - compare living organisms with those in the fossil record - recognize how variation helps or hinders a populations' ability to survive - recognize that extinction occurs when the environment changes and a population is not able to adapt	Interaction with the Environment - describe example of selective breeding and ways that human activities can change populations Health and Disease - explain how various organisms interfere with normal body functions - recognize that many microorganisms can cause specific diseases - recognize that vaccines help build immunity - recognize that the immune system protects against microscopic organisms and foreign substances.
8				
9-12	Levels of Organisms - explain how cells respond to changes in their environment, -describe how organ systems maintain homeostasis in an organism Cells: -describe the primary elements and molecular structures in cells. -recognize the role of proteins, -compare viruses, prokaryotic cells and eukaryotic cells. -explain the function of cell organelles. -compare active and passive transport, -explain the process of mitosis	Ecosystems: - describe the factors that affect carrying capacity - explain how ecosystems can change from the introduction of new species Flow of Energy and Matter: - differentiate between the processes of photosynthesis and respiration - explain how matter and energy is transferred and how energy is dissipated	Reproduction - explain the relationships among DNA, genes and chromosomes - use a monohybrid cross, and to describe the process of DNA replication Variation: - explain how sorting and recombination increases variation - explain the advantages and disadvantages of asexual and sexual reproduction - explain how mutations can result in genetic variation Biological Evolution - describe evidence that led to theories of evolution - use evidence to show the evolutionary relationship among species - recognize that artificial selection can vary offspring - explain how genetic variation is essential for evolution - explain how competition and changing environments promote natural selection - explain how genetic variations lead to new species	Interaction with the environment - describe risks and benefits of biotechnology - describe the risks and benefits of changing a natural ecosystem - describe the contributions from diverse cultures to the understanding of the interactions of humans and living systems Health and Disease - describe how diseases can be predicted by genetic testing - explain how the body produces antibodies and how the immune systems can attack the body's own cells - explain how factors and decisions affect personal health - recognize that a mutation can result in cancer.

High School Science Course Implementation for the 2009 Science Standards

The 2009 Science Standards are banded for grades 9-12, which gives school districts the option to design the configuration of courses that meet the standards and their local goals.

The specific requirements that must be met are:

1. All students must earn 3 credits in science, including at least one credit in biology (Minn.Stat §120B.024 (a)(3)).
    a. The biology course must meet the 9-12 Life Science standards.
    b. Students in the class of 2015 and beyond must include a credit in chemistry or physics (Minn Stat § 120B.023, subd.2 (d)). The course must fulfill the Chemistry or Physics standards in the 2009 standards
    c. An agriculture science or a career and technical education (CTE) course may fulfill a general science credit requirement (elective) (Minn.Stat §120B.024 Subd.5(b, c)); and (Minn Rules 3505.1150).
    d. The school board has the authority to grant a rigorous course of study waiver to students under certain conditions (Minn.Stat§120B.021 Subd.1(a)).
2. All students must satisfactorily complete the state course credit requirements and all state academic standards (2009 Session Law, Chapter 96). All the standards must be included in the common core curriculum that all students take. This includes Nature of Science and Engineering and Earth & Space Science standards.
3. The 2009 standards must be implemented no later than the 2011-12 school year (Minn. Stat. 120B.023, subd. 2 (d)). The Chemistry and Physics standards must be implemented for the graduating class of 2015.
4. The MCA-III Science Assessment at the high school level will cover the Life Science and the Nature of Science and Engineering strands of the 2009 Science Standards starting in the 2011-2012 school year. It will be administered near the end of the year in which the students take the biology class which meets the 9-12 Life Science standards.
5. Courses must be taught by teachers with the proper license. Teachers who have the currently offered license combination of 5-8 General Science and one of the 9-12 science content licenses can teach integrated science courses in high schools. Teachers with 5-8 General Science or 5-9 General Science may teach physical science for 9th graders. CTE courses must be taught by CTE licensed teachers. A list of license requirements for specific courses is at http://education.state.mn.us/MDE/Data/STAR_Staff_Automated_Reporting/Reporting_Documents/index.html.

Several additional factors should be considered in determining the sequence of courses:

1. Sequence of learning – The concepts should build on each other and be at appropriate developmental levels. There is some research that advocates a physics – chemistry – biology sequence to build the concepts that are needed in chemistry and biology. Some people advocate for earth science or environmental science as a culminating course.
2. Prerequisite skills – Students should have appropriate math and other skills. Science courses should align with the math sequence. Some schools are requiring physics for all students at the 11th grade level to help develop skills for the MCA math test.
3. Electives – It is helpful to provide courses that interest students, support career goals or fit a small learning community focus, such as forensic science, anatomy/physiology, environmental science, and CTE courses.
4. Opportunity for advanced science courses, such as Advanced Placement, International Baccalaureate, Post Secondary Education Options, and College in the Schools.
5. Higher Education requirements – Some college programs require specific courses.

Course Scenario Comparisons

The following are sample scenarios that implement the 2009 Science Standards and the requirement of physics or chemistry for the class of 2015 and beyond. **The Nature of Science and Engineering standards should be integrated throughout all science courses.** In many cases, the order of the courses can be switched.

Codes that describe the standards in the courses: AES = astronomy content in Earth & Space Science standards, **CHE** = all Chemistry standards, **CPS** = chemistry content in the Physical Science standards, **ELS** = ecology content in Life Science standards, **ESS** = all Earth & Space Science standards, **GES** = geology content in Earth & Space Science standards, **HES** = historical geology content in Earth & Space Science standards, **LSS** = all Life Science standards, **PHY** = all Physics standards, **PPS** = physics content in the Physical Science standards

	9th	10th	11th	12th	Advantages	Disadvantages
A	Physical Science CPS, PPS	Earth Science ESS	Biology LSS	Physics –PHY or Chemistry- CHE	-close to current practice in many schools -Licensure: 5-8 or 5-9 general science license can teach the 9th grade course -good fit for strands, licenses and math	-4 years of science needed for 2015 requirement. -may need more earth science licensed teachers
B	Physics with Astronomy PPS, PHY, AES	Chemistry with Geology CPS, CHE, GES	Biology LIS, HES	Electives including advanced courses	-preparation for molecular biology -meets 2015 requirement in both chemistry and physics -fits "physics first" philosophy	-may be difficult to meet physics standards in 9th grade (math level) -may need more physics and chemistry licensed teachers
C	Environmental Science CPS, GES ELS	Physics with Astronomy PPS, PHY, AES	Biology LSS + needed chemistry	Chemistry or other electives, including advanced courses	-Licensure: 9th is an integrated science -meets 2015 requirement via physics -9th grade course uses engaging, applied approach	-may need more physics licensed teachers
D	Physical Science with Geology PPS, CPS, GES	Biology LSS + needed chemistry	Physics with Astronomy PHY, AES	Chemistry or other electives, including advanced courses	-physics in grade 11 reinforces skills for math MCA exam -meets 2015 requirement via physics	-may need more physics licensed teachers
E	Physical Science PPS, CPS (1 sem. or 2 trimesters) Earth Science ESS (1 semester or 1tri.)	Chemistry CPS, CHE	Biology LSS, HES	Physics or other electives, including advanced courses	-preparation for molecular biology -meets 2015 requirement via chemistry -earth science standards taught by earth science licensed teachers	-may need more earth science and chemistry licensed teachers
F	Physical Science with Earth Science PPS, CPS, ESS	Biology LSS, HES	Chemistry CHE or Physics PHY or advanced Physics or advanced Chem.	Electives including advanced courses	-if 9th is integrated, can use 5-8 and 5-9 general science licensed teachers -opportunities for advanced courses starting in 11th grade	-may be difficult to accomplish all standards in 9th grade course
G	Earth Science with Physical Science ESS, PPS	Chemistry CHE, CPS	Biology LSS, HES	Physics or other electives, including advanced courses	-meets 2015 requirement via chemistry -preparation for molecular biology -earth sci. standards taught by Earth Sci. licensed teachers	-may need more earth science and chemistry licensed teachers
H	Other scenarios could be developed to integrate standards, for example: the integration of science, math, technology and CTE content.				-content and skills learned in an applied method -preparation for career skills	-licensure requirements

integrated courses solve licensing issue – 7 generalist 5-8 can do 9th grade